

The genus *Azygocypridina* Sylvester-Bradley (Crustacea : Ostracoda) with particular reference to *A. imperialis* (Stebbing, 1901)

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Introduction

This is the first paper in which the adults and juveniles of both sexes of a species of *Azygocypridina* have been described and illustrated together. Previous descriptions of new species have usually been based upon single specimens. Consequently, although nine species of *Azygocypridina* have been described, we still know very little about the genus, and it has not been clear which morphological features characterize individual species or which indicate a particular instar or sex.

One hundred and three specimens of *Azygocypridina imperialis* (Stebbing) were collected during cruises of R.R.S. *Discovery* and R.R.S. *Challenger* in 1971, 1974, 1976, 1978 and 1979 at stations in the N.E. Atlantic (see Table 1). The specimens included both adults and immature instars and were obtained from depths between 1950 m and 2930 m mainly by means of an epibenthic sledge (see Aldred *et al.*, 1976).

Systematic descriptions

Sub-class OSTRACODA Latreille, 1802 (*nom. correct.*, Latreille, 1806)

Order MYODOCOPIDA Sars, 1866

Sub-order MYODOCOPINA Sars, 1866

Family CYPRIDINIDAE Baird, 1850

Sub-family AZYGOCYPRIDININAE Kornicker, 1970 (*nom. nov.* for Crossophorinae Skogsberg, 1920)

Genus AZYGOCYPRIDINA Sylvester-Bradley, 1950

TYPE SPECIES: (by monotypy) *Crossophorus imperator* Brady, 1880

Crossophorus Brady, 1880 : 158

Crossophorus Brady; Brady and Norman, 1896 : 643

Crossophorus Brady; Müller, 1906a : 133 (*non Crossophorus* Hemprich & Ehrenberg, 1828—a nematode—senior homonym)

Azygocypridina Sylvester-Bradley, 1950 : 364 (*pro Crossophorus* Brady, 1880)

DIAGNOSIS. Adult: carapace robust, large (4–15.5 mm), ovate/globular with small rostrum and incisure; no caudal process; margins smoothly rounded; ornament lacking except for minute punctae. Outer lobe of third podomere of fifth limb exopodite bears two setae. 'Minor' spines of furcal lamellae more than half the length of the adjacent 'major' spines.

In male: endopodite of second antenna reflexed; *b*-seta and *c*-seta of first antenna with spoon-like setules.

SPECIFIC DETERMINATION IN *AZYGOCYPRIDINA*. Table 2 summarizes all the published records of species of *Azygocypridina*. With the exception of *A. imperialis* (Stebbing) and *A.*

Table 1 Sampling data for collections of *Azygocypridina imperialis*.

Research Vessel	Cruise No.	Station and Haul No.	Position lat. long.	Depth (m)	Gear	Date
Discovery	39	7709#62	60°N 20°W	2714	sledge*	1.5.1971
Discovery	39	7709#73	60°N 20°W	2633–2646	sledge*	5.5.1971
Discovery	39	7709#85	60°N 20°W	2708	sledge*	7.5.1971
Discovery	39	7711#57	53°N 20°W	2656–2658	sledge*	27.5.1971
Discovery	39	7711#58	53°N 20°W	2615–2621	sledge*	27.5.1971
Discovery	61	8511#1	42°N 11°W	2384–2399	sledge*	5.5.1974
Discovery	61	8512#4	42°N 11°W	2281–2465	sledge*	7.5.1974
Discovery	61	8514#1	42°N 11°W	2622–2632	sledge*	8.5.1974
Discovery	79	9133#5	21°N 18°W	2112–2160	sledge*	25.11.1976
Discovery	79	9133#7	21°N 18°W	2130–2191	otter trawl	26.11.1976
Discovery	79	9134#0	21°N 18°W	1949–1942	sledge*	26.11.1976
Discovery	92	9753#7	51°N 12°W	1942	sledge*	8.4.1978
Challenger	9/79	50605#1	50°N 13°W	2820–2930	sledge*	5.7.1979

*For a complete description of epibenthic sledge see Aldred *et al.*, 1976.

africanus (Stebbing), the descriptions of all these species have been based on single specimens. Differences in the terminal part of the seventh limb and in the number of furcal spines were used by Stebbing (1901) to distinguish *A. imperialis* from *A. imperator* (Brady) and *A. africanus*. Granata (1919) also used numbers of furcal spines, as well as carapace size, to distinguish between *A. grimaldii* (Granata) (= *A. imperialis*), *A. imperator*, *A. gibber* (Müller) and *A. africanus*. Both Müller (1912) and Rudjakov (1961) used the number of setae on the seventh limb to separate species of *Azygocypridina*. McKenzie (1968) used this character, together with shape, to establish a new species which he did not formally name.

Of the characters used for specific determination by earlier authors, the number of furcal spines can be disregarded as being of no taxonomic importance at the specific level in *Azygocypridina*. A comparison of the furcal lamellae from eight adult specimens of *A. imperialis* showed that there can be considerable variation in the numbers and arrangement of spines within a single species, and often between the two furcal lamellae of the same individual (see Table 3). An examination of several specimens of *A. imperialis* showed that, generally, the number of furcal spines increases from eight in the A-5 instar to a maximum of twenty-nine in some adults, presumably by interpolation of 'minor' spines between the 'major' spines at each moult. In Table 3 the numbers in the first column indicate the position, in sequence from the distal end, of the 'major' spines amongst the 'minor' spines. 'Major' and 'minor' spines are distinguished subjectively; the 'major' spines are conspicuously stouter and longer than the 'minor' spines. Where it has been difficult to decide whether spines are 'major' or 'minor', the numbers are shown in brackets.

Table 2 Summary of published records of *Azygocypridina* spp.

Species	Sex Length	Height	Group	Locality	Depth (m)	Temp °C	Substrate	No. of specimens	Reference
<i>A. imparator</i> (Brady)	♂ 8.4	—	I	S. Pacific	2012	2	grey ooze	1 ♂	Brady, 1880
<i>A. africanus</i> (Stebbing)	♀ 11.25–15.5	8.75–13.0	I	S. Africa	165–229	~5	rough bottom with sand and shells	♀♀ and juvenile	Stebbing, 1901, 1902
<i>A. africanus</i> (Stebbing)	♀ 11.0	8.75	I	S. Africa	156	—	—	♀ and juveniles	Müller, 1906a,b
<i>A. gibber</i> (Müller)	♂ 4.0	—	II	Indonesia	1158	—	grey mud with brown liquid surface	1 ♂	Müller, 1906b
<i>A. birnsteini</i> Rudjakov	♀ 9.1	—	II	N. Pacific	1050–1070	—	—	1 ♀	Rudjakov, 1961
<i>A. sp.</i> Rudjakov	♂ 7.5	—	II	N. Pacific	1050–1070	—	—	1 ♂ juvenile	Rudjakov, 1961
<i>A. sp.</i> Kornicker	♀ 8.8*	—	—	N. Pacific	850	3.3	brown mud	1 ovigerous ♀	Kornicker, 1969
<i>A. rudjakovi</i> Kornicker	♂ 10.1	9.0	III	S. Pacific	1411–1450	~3	—	1 ♂	Kornicker, 1970
<i>A. sp.</i> McKenzie	♀ 11.0	7.5	I	Tasman Sea	180	—	—	1 ovigerous ♀	McKenzie, 1968
<i>A. imperialis</i> (Stebbing)	♀ 7.0	—	I	N. Atlantic	2633	2.8	—	1 ♀ juvenile	Brady & Norman, 1896
<i>A. grimaldii</i> (Granata) (= <i>A. imperialis</i>)	♂ 8.0	6.5	I	N. Atlantic	2320	—	—	1 ♂	Granata, 1919; Granata & Caporiacco, 1949
<i>A. imperialis</i> (Stebbing)	♀ 8.33–10.13 ♂ 6.84–8.16	7.33–8.7 5.8–6.8	I	N. Atlantic	1942–2714	—	foraminiferal ooze	103 adult and juvenile ♂♂ & ♀♀	herein

*not 2.2 mm as stated in Kornicker (1969), caption to fig. 9 (pers. comm., Kornicker, 1980).

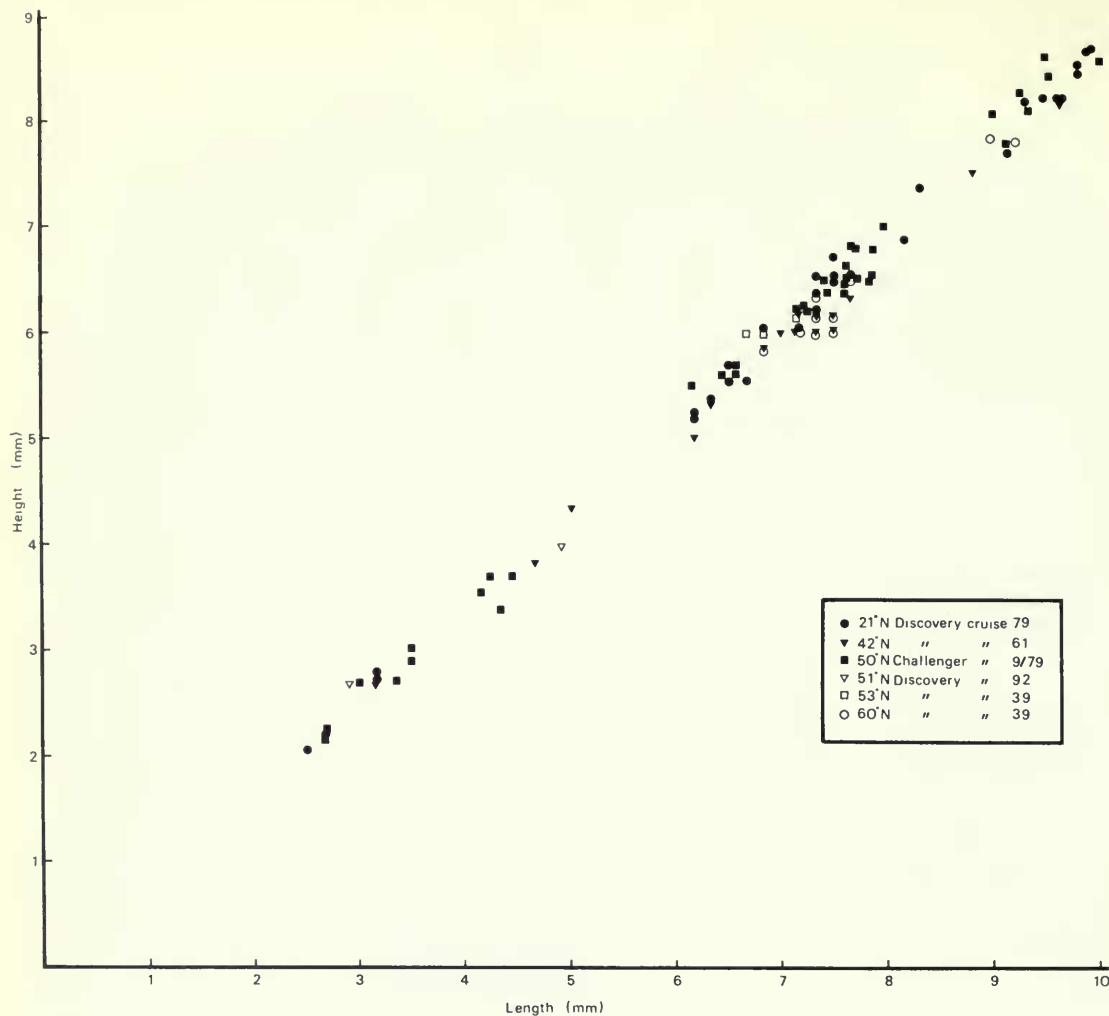


Fig. 1a Size distribution of *Azygocypridina imperialis* (Stebbing) from the N.E. Atlantic.

Müller (1912) considered the number of marginal setae on the seventh limb to be a character of major diagnostic importance, and he recognized three species on this basis. He stated that *A. imperator* had twenty marginal setae, this number being derived from the original description of a single specimen by Brady & Norman (1896). The specimen they examined, however, was subsequently recognized as being distinct from *A. imperator* s.s., was renamed *A. imperialis* by Stebbing (1901), and is shown herein to be A-2 σ instar. An examination of several adult specimens of *A. imperialis* showed that the male bears about forty setae, and the female about sixty setae, marginally. Müller (1912) also stated that *A. africanus* (female) bore one-hundred marginal setae. However, a single female specimen of this species examined by the present author was found to have about three times this number of setae. Müller (1906b, 1912) reported finding sixty setae in *A. gibber* (male), and McKenzie (1967) found about three hundred setae in his *A. sp.* (female). These inconsistencies suggest that specific diagnoses of *Azygocypridina* based solely upon the number of setae on the seventh limb are open to doubt.

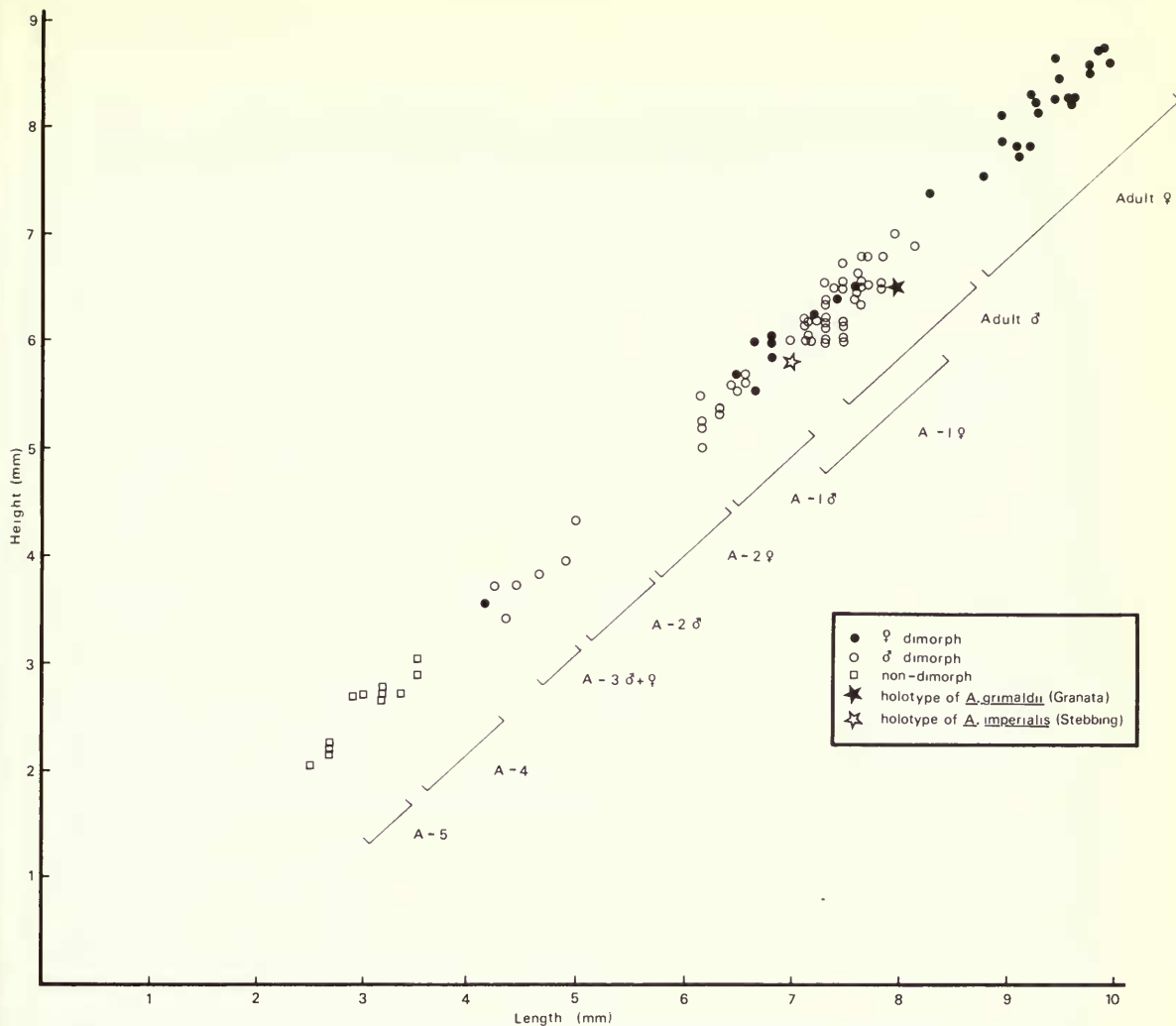


Fig. 1b Ontogenetic sequence of *Azygocypridina imperialis* (Stebbing) from the N.E. Atlantic. The sizes of the holotypes of *A. imperialis* and *A. grimaldii* (Granata) are included for comparison.

Kornicker (1970) arranged all the known species into three groups based on the morphology of the terminal part of the seventh limb (see Table 2). In *A. imperialis* the male and female seventh limbs terminate in markedly different structures (see Figs 6B, D-F). Both sexes do fit into Kornicker's Group I, but care should be taken in using this character in classification until both sexes of the species being determined are known.

Size and shape of the carapace are considered to be poor specific characters for most species. Exceptions are *A. sp.* of McKenzie (1968) which is distinctively ovate and *A. africanus* which is the largest species yet discovered. It may be possible to recognize *A. gibber* by its small size (about 4.00 mm long) but in all other species neither size nor shape is sufficiently distinctive to be of use at the specific level of diagnosis. No relationship seems to exist between water depth and size or shape, but each known species appears to have a distinct geographical range.

Table 3 Distribution of 'major' and 'minor' furcal spines in eleven specimens of *Azygocypridina imperialis*.

The numbers indicate the position, in sequence from the distal end, of the 'major' spines amongst the 'minor' spines. Where it has not been possible to decide whether spines are 'major' or 'minor', the numbers are shown in brackets.

Position of 'major' spines	Total number of furcal setae	Sex and instar	Station and Haul Nos.
L 1 2 5 8 12 15 17	26	A♂	7709#85
R 1 2 6 9 12 14 16 18 20	27		
L 1 2 5 (6) 9 12 14 18	24	A♂	8511#1
R 1 2 5 9 12 14 16 18	24		
L 1 2 5 8 11 14 16	23	A♂	7709#73
R 1 2 5 8 11 13	23		
L 1 2 5 8 11 13 15	24	A♂	7709#73
R 1 2 5 8 11 14 16	24		
L 1 2 (3) 6 10 13 16 (18)	26	A♂	7709#73
R 1 2 6 10 14 17 19	28		
L 1 2 6 9 12 14	22	A♂	7709#73
R 1 2 6 10 13 15	24		
L 1 2 5 8 11 13 15	22	A♂	7709#73
R 1 2 5 (6) 8 10 12 14 16	22		
L 1 2 6 8 10 13 16 18	25	A♀	8511#1
R 1 2 6 8 11 15 18 20 (22)	29		
L 1 2 5 8 12 15 (17)	24	A-1♂	8511#1
R 1 2 6 9 12 15 (17)	22		
L 1 2 (3) 5 7 9 11	16	A-2♂	8514#1
R 1 2 5 7 9 11	18		
L 1 2 3 4 5 6 7 8	8	A-3♀	8514#1
R 1 2 3 4 5 6 7 8	8		

Azygocypridina africanus (Stebbing), 1901

Crossophorus africanus Stebbing, 1901 : 100 (no illustration)

Crossophorus africanus Stebbing; Stebbing, 1902 : 79; pls 15a, 16.

Crossophorus africanus Stebbing; Müller, 1906a : 134; pl. 34, figs 1-9.

Azygocypridina africanus (Stebbing), Sylvester-Bradley, 1950 : 364 (new combination).

LECTOTYPE. (designated herein). A female carapace (15.0 mm long) and appendages. Brit. Mus. (Nat. Hist.) No. 1928. 12.13064.

TYPE LOCALITY. Mosselbaai, S. Africa, approx. lat. 34°12'S, long. 22°08'E; collected by a Dr Gilchrist aboard the *Peter Faure*; depth 90-100 fms (164-182 m).

DISTRIBUTION. S. Africa (Stebbing, 1901, 1902; Müller, 1906a); found at depths of between 156 m and 229 m; temperature about 5°C; associated with a rough substrate of sand and shells.

DIAGNOSIS. Characteristic setal complement of first and second antennae (see Fig. 2). Seventh limb of the adult female bears about 300 setae marginally and terminates in an

inflated tip, divided into two opposing 'jaws', one of which terminates in a group of about 10 teeth, the other in a single hooked 'tooth'. Each 'jaw' bears a cluster of 30–40 setae. Length : height : breadth ratio of adult female carapace is about 100 : 86 : 54. Adult male unknown.

Table 4 Mean carapace dimensions of adults and A-1 instars of *A. imperialis* and *A. africanus* (see p. 156).

Number of Specimens	Species	Sex	Length	Height	Breadth
28	<i>A. imperialis</i>	♂	7.3 (100)	6.2 (82)	4.25 (67)
13	<i>A. imperialis</i>	♀	9.5 (100)	8.0 (85)	6.1 (64.5)
5	<i>A. imperialis</i>	A-1♂	6.23 (100)	5.2 (83.5)	4.0 (64)
4	<i>A. imperialis</i>	A-1♀	6.63 (100)	5.66 (85.4)	4.33 (65.3)
1	<i>A. africanus</i>	♀	15.0 (100)	12.9 (86)	8.1 (54)
1	<i>A. africanus</i>	A-1♂	10.8 (100)	9.18 (85)	6.37 (59)

Azygocypridina imperialis (Stebbing), 1901
(Figs 4–11)

Crossophorus imperator Brady; Brady & Norman, 1896 : 643, pl. 53, figs 1–11. (*non C. imperator* Brady, 1880 : 158)

Crossophorus imperialis Stebbing, 1901 : 100.

Crossophorus grimaldii Granata, 1919 : 1, text-figs 1–7.

Crossophorus grimaldii Granata; Granata & Caporiacco, 1949 : 5; pl. 1, fig. 1; pl. 2, figs 1–12.

Azygocypridina imperialis (Stebbing); Sylvester-Bradley, 1950 : 364 (new combination).

HOLOTYPE. Female juvenile (A-2 instar); appendages and carapace fragments: B.M.(N.H.) 1911.11.8.3901, 1911.11.8.36759.

TYPE LOCALITY. 'Porcupine' station no. 20 (approx. lat. 55°11'N, long. 11°31'W); depth 1443 fathoms (2639 m); temperature 2.8°C, date 1869.

DISTRIBUTION. N.E. Atlantic, 1900–2930 m, associated with foraminiferal ooze.

REMARKS. In 1919, Granata introduced *Crossophorus grimaldii* as a new species, based on a single adult male specimen from the N.E. Atlantic. The original description was brief and accompanied by a few poor illustrations. Granata and Caporiacco, 1949, reillustrated the same specimen, which by this time had been lost. Comparison of these latter illustrations with my own specimens strongly suggests that *C. grimaldii* is identical to and, therefore, a junior synonym of, *A. imperialis*. Moreover, Granata's specimen was collected from the same geographical area as the 'Discovery' and 'Challenger' material.

DIAGNOSIS. Adult; characteristic setal complement of the first and second antennae (see Fig. 2). Seventh limb of male has about forty marginal setae and terminates in paired 'jaws', each with a cluster of about ten setae. One 'jaw' bears three stout 'teeth', the other a single hooked 'tooth'. Seventh limb of female has about sixty marginal setae and terminates in two opposing 'jaws', one with three 'teeth', the other with a large hooked 'tooth' and about eight short 'teeth'. Length : height : breadth ratio of ♂, 100 : 82 : 67; of ♀, 100 : 85 : 64. Carapace almost circular in lateral view, highly inflated, with no obvious ornamentation; surface finely punctate and bearing rimmed pores, some with, and others without, marginal protuberances. Rostrum small, acuminate; incisure parallel-sided, moderately deep. Muscle scar pattern consists of five more-or-less vertically elongate scars in a horizontal row, with a

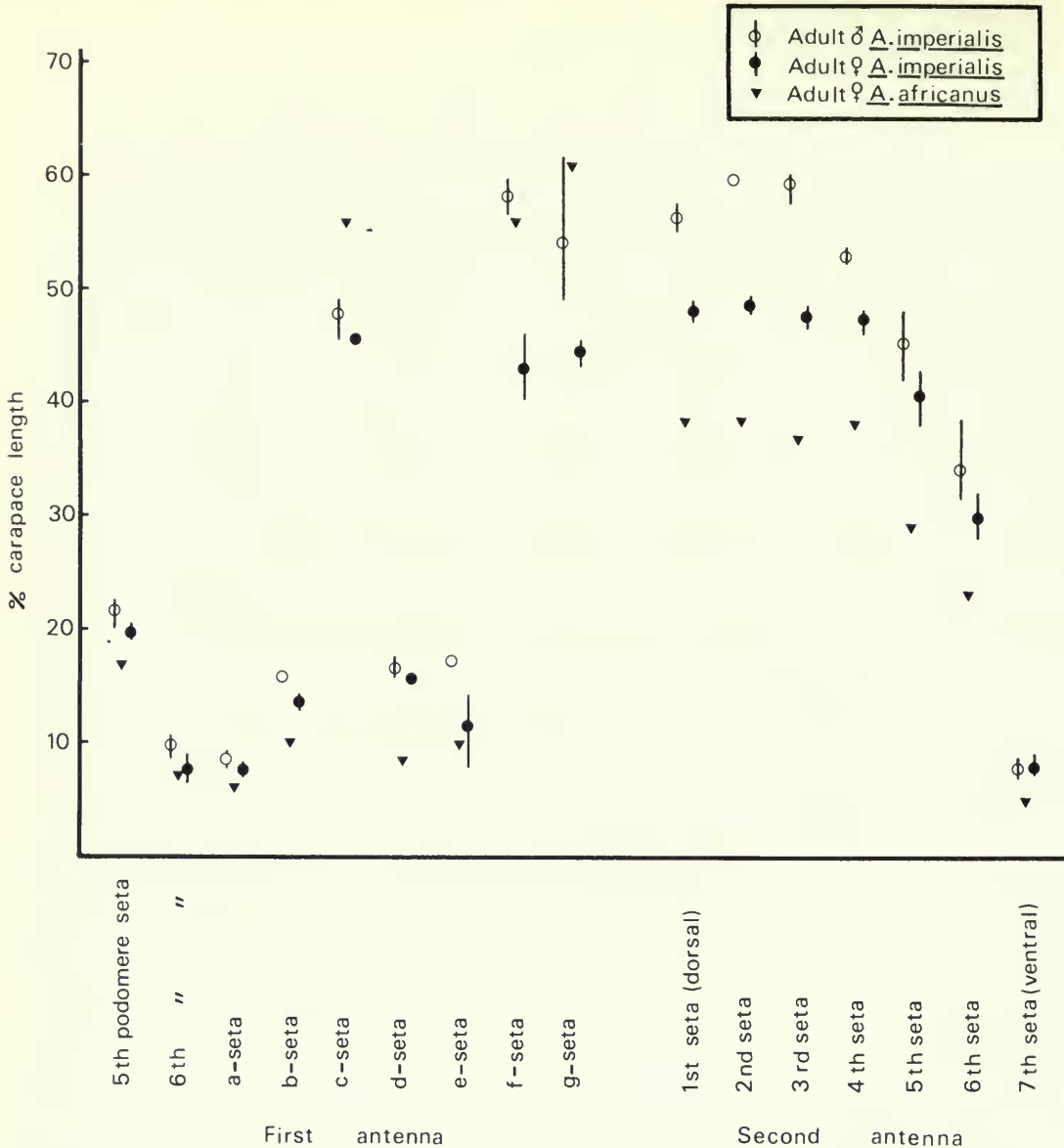


Fig. 2 Comparison of the meristic characters of the 1st and 2nd antennae of adult specimens of *A. imperialis* and *A. africanus*.

The mean lengths of setae from the left and right appendages of two specimens of *A. imperialis* are shown together with their observed ranges. These values are compared with measurements from a single adult female of *A. africanus*. All measurements are expressed as percentages of the mean carapace length.

curved cluster of eight or nine round/slightly elongate scars posteriorly; U-shaped anterior muscle scar. Freshly caught specimens observed in the net have orange soft parts and milky-white translucent carapaces (Angel, pers. comm.). With back lighting in the laboratory they appear to have red bodies whilst the carapaces are tinted purple.

Appendages of adult *A. imperialis*

Examination of appendages from several specimens of both sexes showed that the number of

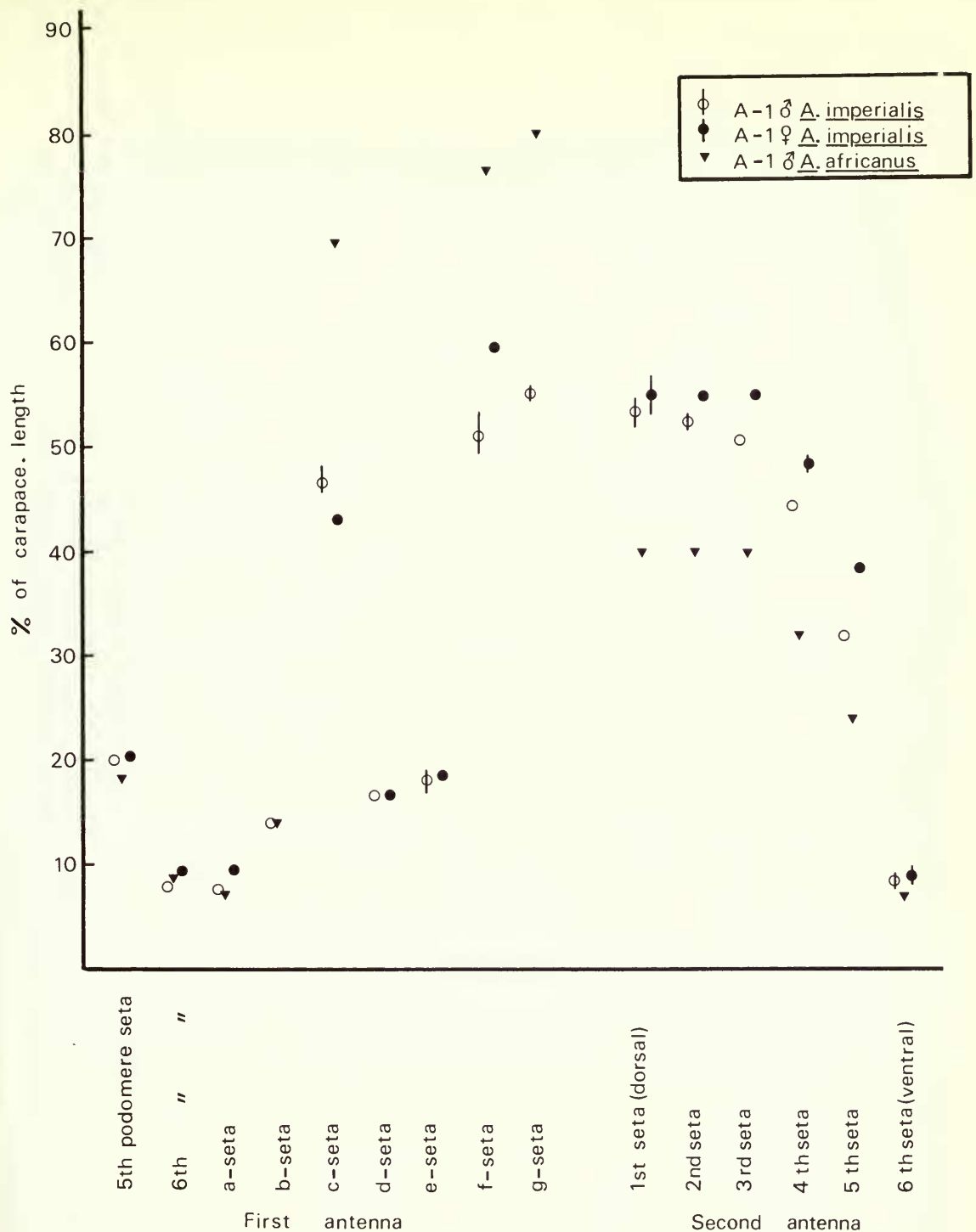


Fig. 3 Comparison of the meristic characters of the 1st and 2nd antennae of A-1 instars of *A. imperialis* and *A. africanus*.

The mean lengths of setae from the left and right appendages of two specimens of *A. imperialis* are shown together with their observed ranges. These values are compared with measurements from a single A-1 male of *A. africanus*. All measurements are expressed as percentages of the mean carapace length. (Data incomplete for both species.)

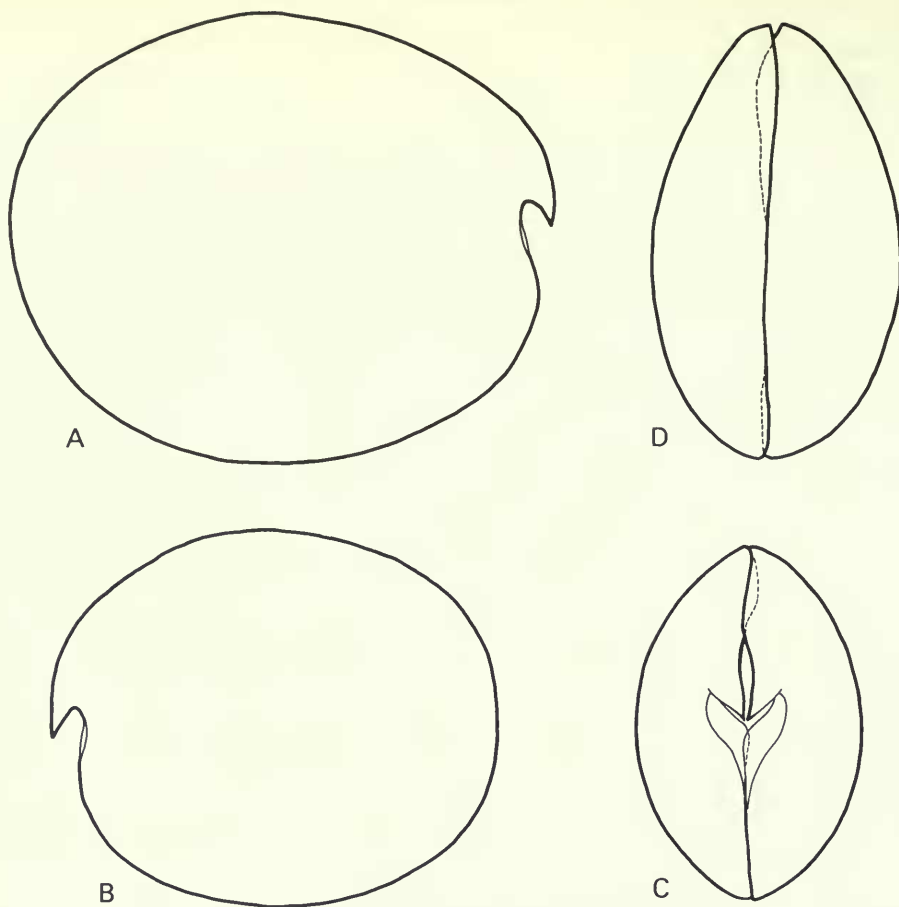


Fig. 4 *Azygocypridina imperialis* (Stebbing). A-D carapace profiles: A, female, right valve, external; B, male, left valve, external; C, male, carapace, anterior; D, male, carapace, dorsal.

small setae varied from one individual to another and, sometimes, between left and right appendages of the same individual. Table 3 shows the individual variations in the setal complement of the furcae. In other appendages variation in setation may have resulted from loss of setae during the preparation of specimens for examination. In general, differences in the setal complement of appendages are not an expression of sexual dimorphism in *A. imperialis*. Obvious exceptions to this are to be found in the first and second antennae, and in the seventh limb. (See section on Ontogeny and Sexual Dimorphism.)

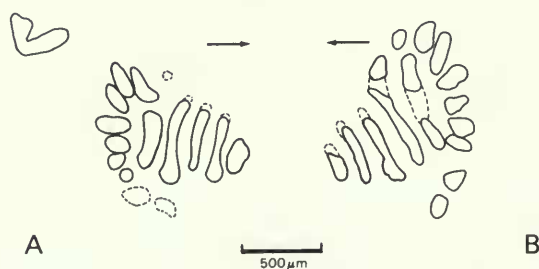


Fig. 5 *Azygocypridina imperialis* (Stebbing). Muscle scar patterns: A, female, left valve internal; B, male, right valve internal. Arrows point anteriorly.

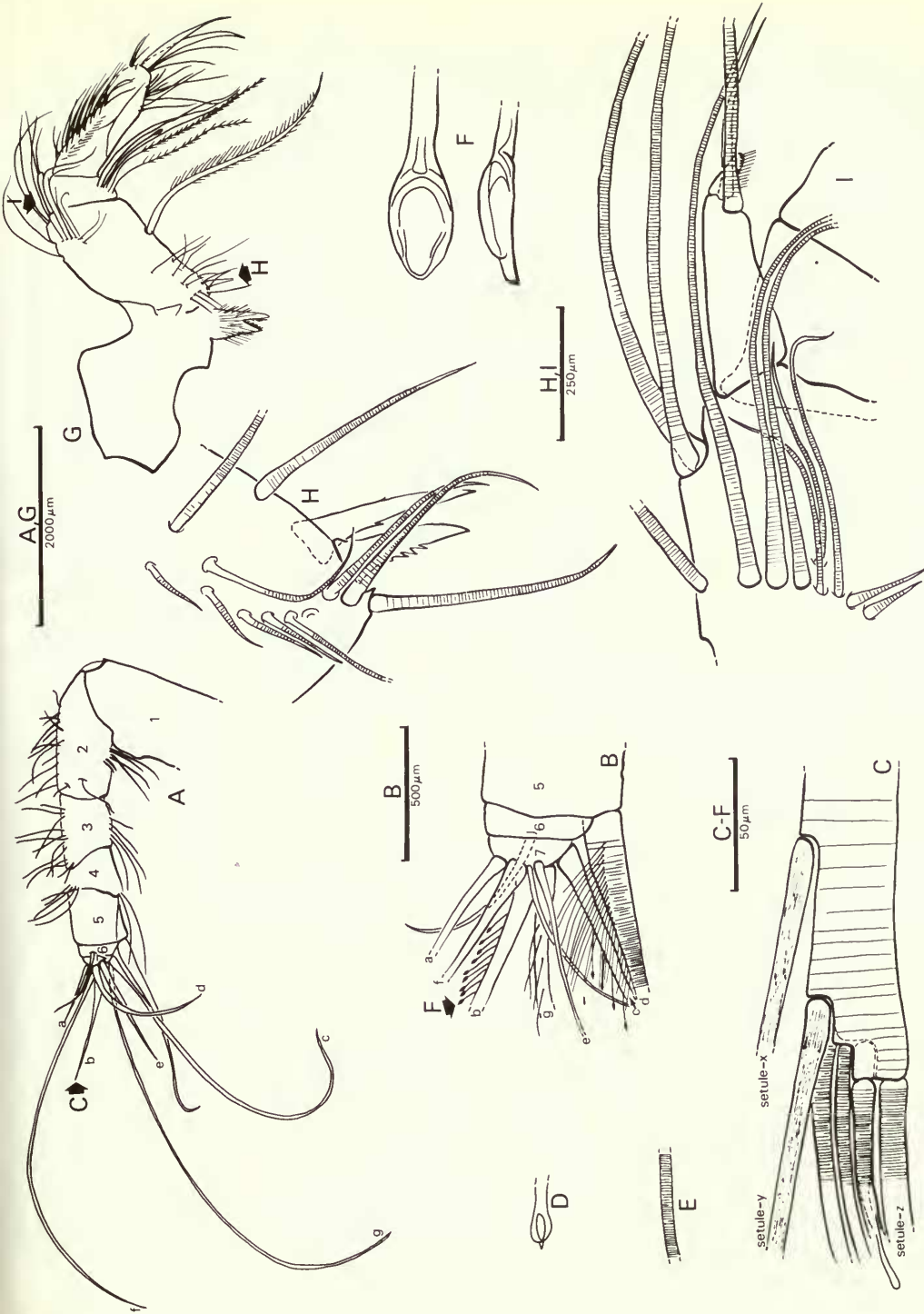


Fig. 6 *Azygocypridina imperialis* (Stebbing)
A-F: male, first antenna B.M.(N.H.) 1979.231
A: whole appendage
B: details of setae borne on podomeres 5-7
C: tip of *b*-seta
D: tip of setules 'x' and 'y' of *b*-seta

E: tip of setule 'z' of *b*-seta
F: tip of spoon-like setules of *b*-seta
G-I: female, mandible B.M.(N.H.) 1979.232
G: whole appendage
H: details of ventroproximal part of basale
I: details of dorsodistal part of basale

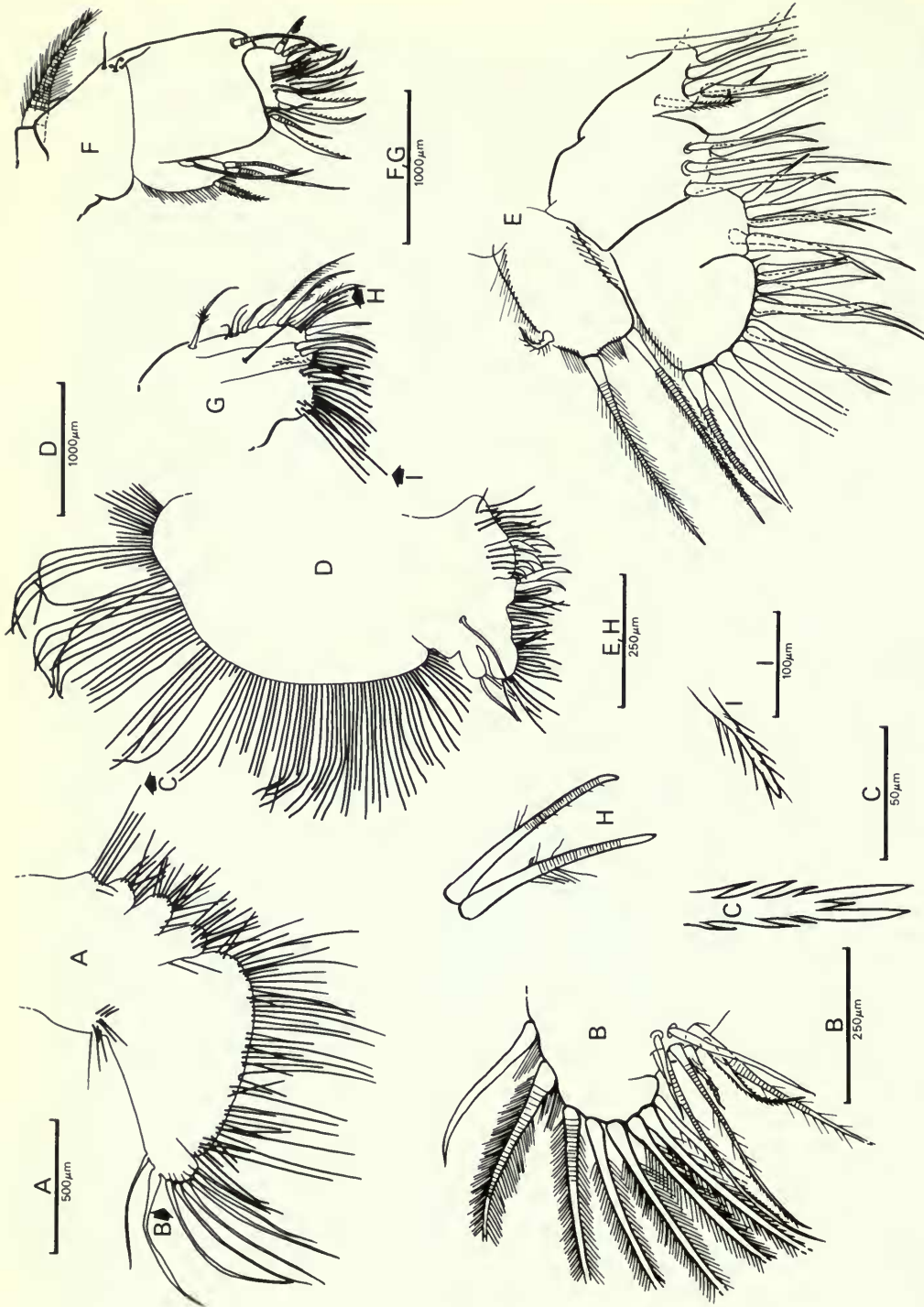


Fig. 7 *Azygocypridina imperialis* (Stebbing)
 A-C: sixth limb, male, B.M.(N.H.) 1979.233
 A: whole appendage
 B: details of terminal podomere
 C: tip of triaenid seta of 'A'
 D: female, fifth limb, whole appendage B.M.(N.H.) 1979.234

E: male, fifth limb, details of exopodite B.M.(N.H.) 1979.233
 F-I: male maxilla B.M.(N.H.) 1979.231
 F: limb without endites
 G: endites
 H: setae from 'G'
 I: seta from 'G'

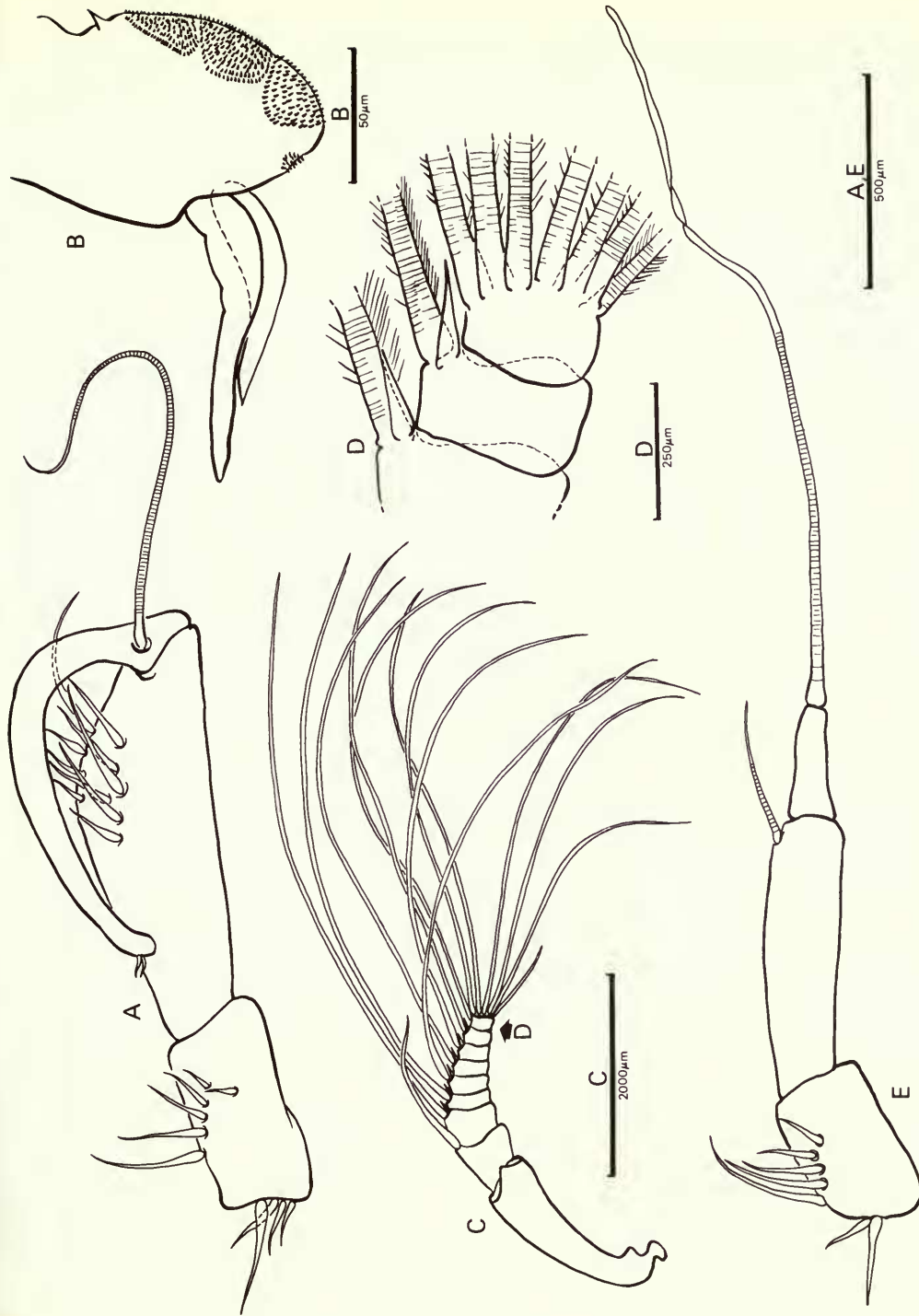


Fig. 8 *Azygocypridina imperialis* (Stebbing)
 A, B: male second antenna B.M.(N.H.) 1979.233
 A: endopodite
 B: detail of tip of third podomere of endopodite
 C-E: female second antenna B.M.(N.H.) 1979.232
 C: exopodite
 D: detail of podomeres 7-9 of exopodite
 E: endopodite

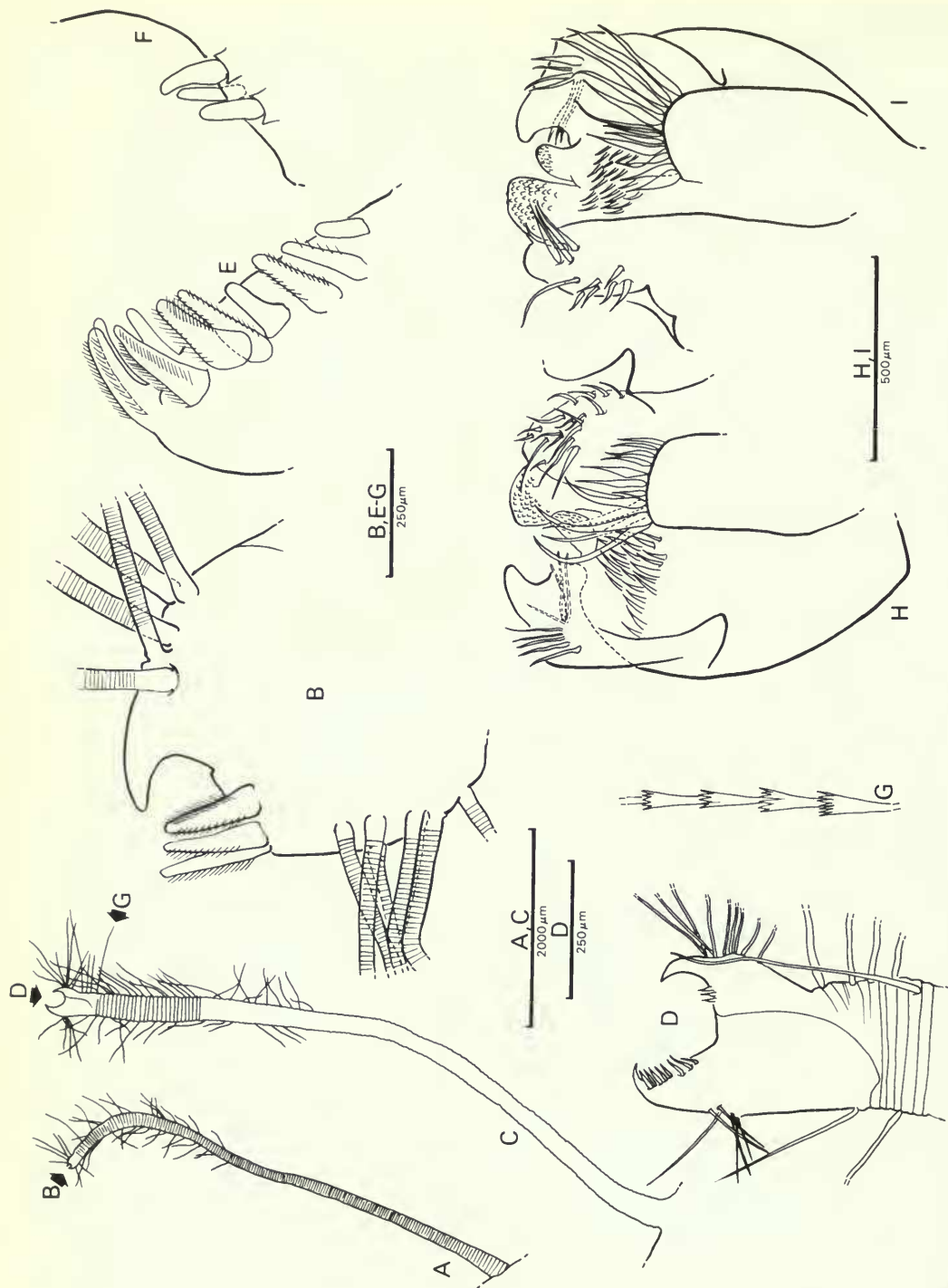


Fig. 9 *Azygocypridina imperialis* (Stebbing)
 A, B: male, seventh limb B.M.(N.H.) 1979.231
 A: whole appendage
 B: detail of tip of 'A'
 C-G: female, seventh limb B.M.(N.H.) 1979.232

C: whole appendage
 D: detail of tip of 'C'
 E, F: detail of tip of 'D'
 G: bell-shaped seta from 'C'
 H, I: male, copulatory appendages B.M.(N.H.) 1979.233

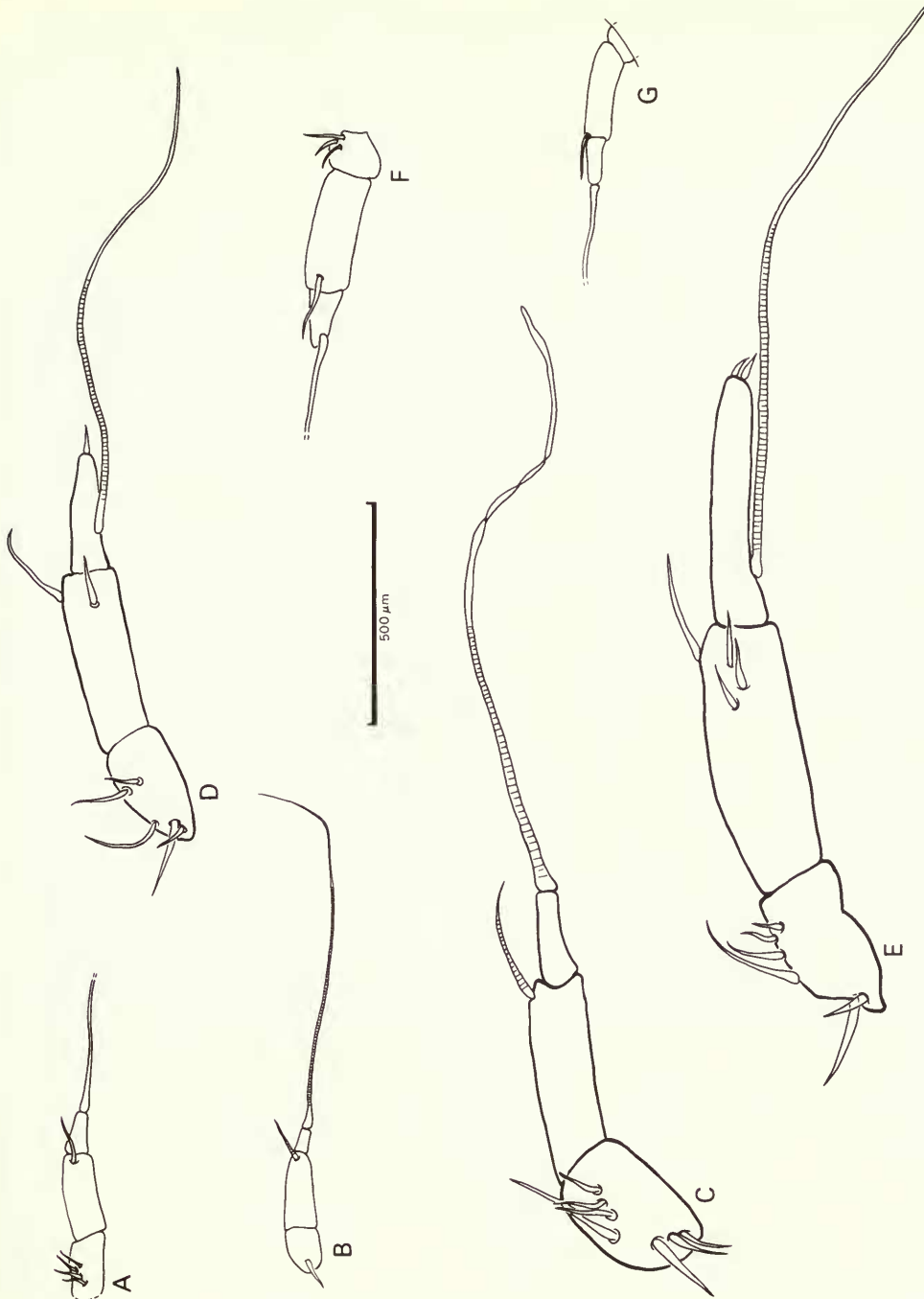


Fig. 10 *Azygocypridina imperialis* (Stebbing)
 A-G: juveniles, endopodite of second antenna
 A: female A-2 (holotype) B.M.(N.H.) 1911.11.8.3901
 B: female A-3 B.M.(N.H.) 1979.235
 C: female A-1 B.M.(N.H.) 1979.236
 D: male A-2 B.M.(N.H.) 1979.237
 E: male A-1 B.M.(N.H.) 1979.238
 F: male A-3 B.M.(N.H.) 1979.434
 G: A-4 B.M.(N.H.) 1979.435

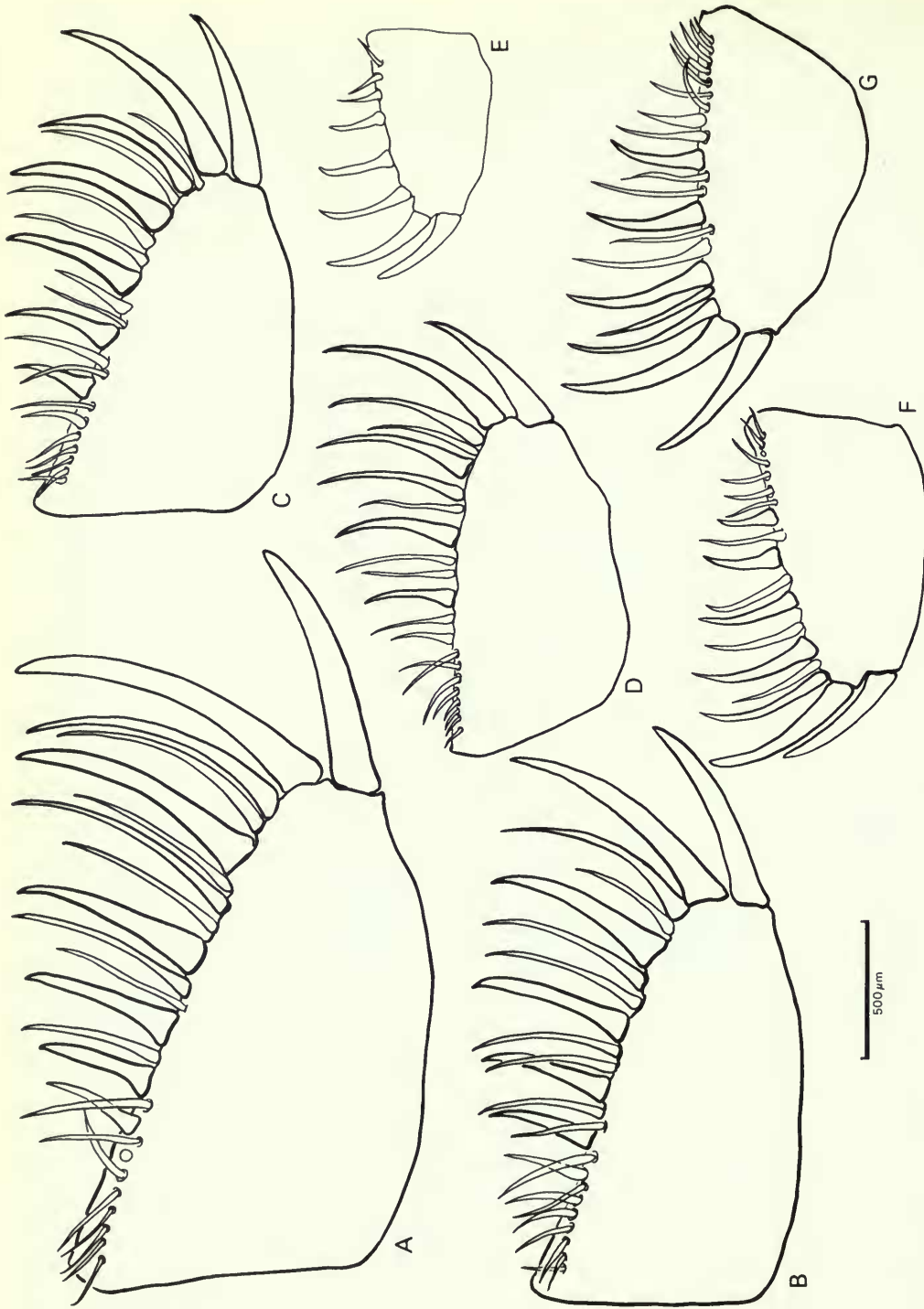


Fig. 11 *Azygocypridina imperialis* (Stebbing)

A-G: caudal furcae

A: female adult B.M.(N.H.) 1979.232

B: male adult B.M.(N.H.) 1979.239

C: male A-1 B.M.(N.H.) 1979.240.

D: female A-2 (holotype) B.M.(N.H.) 1911.11.8.3901

E: female A-3 B.M.(N.H.) 1979.235

F: male A-2 B.M.(N.H.) 1979.241

G: female A-2 (holotype) B.M.(N.H.) 1911.11.8.3901

The terminology used in the following descriptions is based on the comprehensive study of cypridinids by Skogsberg (1920) to which reference should be made for a discussion of structure, function and homology of the appendages. The letter notation of homologous setae, introduced by Skogsberg and adopted by Poulsen (1962) and Kornicker (1970, 1975), is used for the description of the first antennae, but not for other appendages, where the homologies between setae are less readily recognized.

First antenna. This appendage is seven-jointed and geniculate. The proximal ventral margin of the second podomere bears a cluster of seven setae; there are two short setae laterally, anterior to the previous group, and two other setae laterally and subterminally; there are about twenty setae on or near the dorsal margin. The third podomere carries seven setae ventrally and eighteen setae dorsally. The fourth podomere bears, distally, five ventral and five dorsal setae. Ventro-distally the fifth podomere has a long, annulate seta which bears many fine, filamentous setules. The sixth podomere has a single short, medial seta. The seventh podomere bears seven setae. The *a*-seta is short and finely pinnate; the *b*-seta is almost twice as long and bears, dorsally, numerous long, filamentous setules which in the male have spoon-like tips; the *c*-seta is about three times the length of the *b*-seta, bears identical, but fewer, setules, and is similarly dimorphic; the *d*-seta and *e*-seta are about the same length as the *b*-seta; the *f*-seta is about twice the length of the fifth podomere seta; the *g*-seta is slightly longer than the *f*-seta and bears numerous, long, filamentous setules.

Second antenna. The male endopodite is three-jointed, the first podomere bearing one long and three short setae proximally and six setae of different lengths medially. The second podomere carries a cluster of about ten setae medially. The third podomere is inflated and recurved with a long annulate seta arising proximally and with two short terminal setae. The female endopodite has a first podomere similar to that of the male. The second podomere bears a single annulate seta distally which is as long as the third podomere. The third podomere bears a long annulate seta terminally. The exopodite in both sexes is nine-jointed. The second to ninth podomeres each carry a long, strongly pinnate seta distally on the dorsal margin. In addition, the ninth podomere bears six other similar setae of varying lengths, the ventral one being much shorter than the others.

Mandible. The coxale endite is finely hirsute with two pectinate, terminal spines. The proximal ventral margin of the basale bears two stout, pectinate spines and about fourteen slender setae of varying lengths. Mid-ventrally there is a long, stout, pinnate seta. Distally, about 6–8 annulate setae of varying lengths form a curved row reaching the dorsal margin which bears three long, annulate setae, two distally and one medially. The exopodite carries two long, terminal setae ventrally, the proximal one being the longer. The first podomere of the endopodite bears six setae on the ventral margin, two being noticeably pinnate and another, shorter than the rest, terminating in a prominent aesthathasc. The second podomere carries a cluster of twenty to thirty setae dorsally and ten setae distally on the ventral margin. The endopodite terminates in two stout, chelate setae together with about four short setae.

Maxilla. The coxale bears a single, stout, hirsute seta. The exopodite bears two long, naked, terminal setae and a single shorter, annulate, pinnate seta on its outer margin, which is hirsute. The basale carries a single long, naked, annulate seta subterminally near to the base of the exopodite and one long, naked, annulate seta near the base of the third endite. The medial margin bears about five to seven short setae. The endopodite carries about nineteen setae on two podomeres. Some are pectinate, some pinnate and others naked and annulate or filamentous. The first endite bears about sixteen long setae marginally, many with triaenid tips, and about four short medial setae. The second endite has numerous stout setae medially, about five fine setae terminally and two stout setae sub-terminally. There is a single long proximal seta. The third endite bears about thirteen varied setae marginally.

Fifth Limb. The epipodial vibratory plate carries about one hundred setae and the endites bear numerous, varied setae. The outer lobe of the third podomere of the exopodite is hirsute

and bears two hirsute, annulate setae terminally and one short, hirsute seta medially. The fourth podomere bears six naked, annulate setae on the distal lobe. The fifth podomere bears twelve hirsute, annulate setae on the distal lobe and eight naked, annulate setae on the proximal lobe.

Sixth Limb. The epipodial appendage consists of nine setae. The terminal podomere is divided, the distal lobe bearing eight pinnate setae, the proximal lobe bearing at least fifty-four setae of various types, some pinnate, others hirsute or naked. The first endite has six setae, the second has eight and the third has seventeen setae. The fourth endite bears ten setae terminally and two setae medially.

Seventh Limb. In the male, the seventh limb is vermiform and annulate, and bears about forty marginal setae distally. The terminal part consists of paired jawlike processes. One bears three stout 'teeth', the other a single hooked 'tooth'. The seventh limb of the female is similar but bears sixty marginal setae and the 'jaws' bear nine and six setae. In both sexes the distal portion of each marginal seta bears up to eight 'bells'.

Furcae. Between twenty-two and twenty-nine strong chelate spines are borne on each lamella. The first spine is always shorter than the second. The 'major' and 'minor' spines are irregularly arranged (see Table 3). The 'minor' spines are always more than half the length of the 'major' spines.

Brush-like appendage. This is elongate and bears about twelve terminal setae. Absent in the female.

Male copulatory appendage. Each of the paired appendages has a small squat penis. The outer lobe of each appendage bears numerous, stout setae and a distal hooked process bearing about four or five setae on each flank. The inner lobe bears numerous setae and has a globular, serrated lip.

Comparison of *A. imperialis* and *A. africanus*

Table 4 shows the mean dimensions of the carapace of adult and A-1 instars of *A. imperialis* and *A. africanus*. The numbers of specimens measured for this comparison are shown and the dimensions are expressed both as absolute values (in mm) and as a percentage of carapace length (in brackets). Adult and juvenile males and females of *A. imperialis* have very similar shapes. *A. africanus* (both female and A-1♂) is much larger and somewhat less inflated than *A. imperialis* but has a similar profile in lateral view.

A comparison of *A. imperialis* and *A. africanus* revealed several specifically diagnostic meristic characters of the antennae (see Fig. 2). The female *A. africanus* has, proportionately, much larger *c*-, *f*- and *g*-setae, and much shorter *d*-setae on the first antennae than either sex of *A. imperialis*. In addition, the terminal seta of the exopodite of the second antenna is comparatively much shorter in *A. africanus*. These differences are also seen when comparing the antennae of A-1 males of each species (see Fig. 3). Other small differences in relative length of antennal setae may eventually prove to be specifically diagnostic characters, but more specimens must be measured before this can be decided with certainty. Comparative measurements of at least twenty specimens of each species would be required.

Ontogeny and sexual dimorphism in *Azygocypridina*

The size distribution of one hundred and three specimens of *A. imperialis* from the N.E. Atlantic is shown in Figures 1a and 1b. No geographical grouping of specimens collected at different latitudes is apparent (Fig. 1a). Since some overlap in carapace size between instars was found, specimens were allocated to the sex and instar groups shown in Text-figure 1b on the basis of anatomical differences in the 2nd antenna.

All the adult specimens of *A. imperialis* examined, and all adults of previously described *A. spp.*, bear seven setae terminally on the exopodite of the second antennae. A-1, A-2, A-3, A-4 and A-5 instars of *A. imperialis* were found to have 6, 5, 4, 3 and 2 setae, respectively, in this position.

The addition of a seta at each moult is probably a feature common to all species of *Azygocypridina*. An examination by the author of a male *A. africanus*, which on the basis of carapace size was consistent with being an A-1 instar, showed that there were six setae terminally. A single juvenile from within the carapace of a female *A. africanus*, examined by Stebbing (1901), had only a single terminal seta, which suggests that it was an A-6, or earlier, instar.

Dimorphism of the second antennae was used to determine the sex of adults and juveniles of *A. imperialis*. At all stages from A-5 to adult the third podomere of the endopodite of the 2nd antenna of both sexes bears a long seta. In females this seta arises terminally whereas in males it is non-terminal. This sexual dimorphism first appears in the A-3 instar, at which stage the seta in males is only just non-terminal. (See Fig. 10F.) In subsequent male instars the podomere becomes progressively stouter while the seta arises proportionately further from the distal end. In adult males, the third podomere is grossly enlarged and recurved, the seta arising basally (see Fig. 8A). All specimens of the A-4 and A-5 instars examined had terminal setae. While it is possible that all of these specimens were females, it is more likely that *A. imperialis* does not exhibit sexual dimorphism of the 2nd antennae until the A-3 instar since even at that stage, the sexual dimorphism is not pronounced.

Sexual dimorphism at the adult stage is not confined to the anatomy of the 2nd antenna. The *b*- and *c*-setae of the first antennae have spoon-like tips in the male, but pointed tips in the female; the seventh limb of the sexes differs most noticeably in the number of marginal setae, and in the structure of the terminal 'jaws' (see diagnosis for detailed description); paired copulatory appendages and brush-like organs are possessed by the male alone.

Carapace dimorphism is distinct at the adult stage, females being much larger than males. At the A-1 stage there is some overlap of the size ranges of the male and female groups (see Fig. 1b), but in general the females tend to be larger than the males. No A-2 females were found. At the A-3, A-4 and A-5 stages no sexual dimorphism of the carapace was observed.

Brooks (1886), working on Stomatopoda, postulated that the relationship between the carapace lengths of successive instars was a geometric progression with a ratio (growth factor) of approximately 1.25. Fowler (1909), who was the first to apply this concept to the Ostracoda, found that the growth factors of some halocyprid species ranged from 1.26 to 1.78. Przibram (1931) suggested that an increase in linear dimensions at each moult by a factor of 1.26 (i.e. $3\sqrt{2}$) results from the doubling of carapace volume after ecdysis. This relationship exists only when the shape of the carapace remains constant from one instar to the next. Anderson (1964) has suggested that the figure of 1.26 may be a statistical artifact. Using an alternative logarithmic method, he has shown that there is a wide variation around 1.26 in the growth factors of different ostracod species.

The carapace of *A. imperialis* retains the same subspherical shape in successive instars, a fact that can be demonstrated by a simple comparison of length : height : breadth ratios for a series of instars. From the results recorded in Table 5 it appears that there is considerable variation in the growth factors of instars of *A. imperialis*, indicating that the volume enclosed by the carapace is not exactly doubled at each moult. However, the average growth factor for the species is 1.27, the value for females being 1.29 and for males, 1.23. The mean growth factor for the maturation moult is much higher for females than for males. Presumably, this additional increase in volume by females provides space for the storage of ova within the carapace.

The holotype of *A. imperialis* bears 5 terminal setae on the exopodite of its second antenna. This number of setae is indicative of an A-2 instar. The length of the carapace, given by Brady and Norman (1896) as 7.00 mm is greatly in excess of the length expected for an A-2♀ instar of *A. imperialis*. Brady and Norman's measurements may have been inaccurate due to the distortion of the specimen in the net. Alternatively, this specimen may

Table 5 Mean and range of carapace lengths and mean growth factors of 103 specimens of *Azygocypridina imperialis*.

	Adult ♀	Adult ♂	A-1 ♀	A-1 ♂	A-2 ♀	A-2 ♂	A-3 ♀	A-3 ♂	A-4	A-5
Mean Length (mm)	9.48	7.45	6.98	6.36	—	4.87	4.22	4.39	3.12	2.66
Length Range (mm)	8.33–10.13	6.84–8.16	6.50–7.65	6.16–6.65	—	4.70–5.00	4.22	4.30–4.50	2.90–3.52	2.50–2.72
Mean Growth Factor	1.36	1.17	—	1.31	—	1.11	1.35	1.4	1.17	—
Number of Specimens	21	44	9	10	—	3	1	3	8	4

be an exceptionally large A-2♀. Unfortunately, only fragments of the carapace of Brady and Norman's specimen remain and it is, therefore, impossible to verify their recorded measurements.

Fecundity of *Azygocypridina*

In common with other cypridinids, females of *Azygocypridina* spp. retain clusters of ova within the carapace until hatching occurs. Four specimens of *A. imperialis* examined were ovigerous females. One was left unopened but the other three were found to contain respectively 31, 42 and 65 ova, all about 0.45 mm in diameter, within the posterior part of the carapace. Ova of similar size were observed by the present author within the carapace of an unopened specimen of *A. africanus*.

Stebbing (1901) reported finding some early instars inside a specimen of *A. africanus*, but he did not observe any ova. Kornicker (1969) and McKenzie (1968) both reported the presence of ova within the carapaces of their species of *Azygocypridina*, but they did not indicate the size of the clutches. However, McKenzie stated that the ova were numerous and about 0.15 mm in diameter. Examination of the lectotype of *A. africanus*, designated herein, revealed about 120 sub-spherical cells, about 0.15 mm in diameter, adhering to the marginal setae of the seventh limb and to other appendages. Similar cells are not uncommon in midwater halocyprids and are thought to be epibionts (Angel, pers. comm.). Thus, McKenzie's 'ova' may have been similar epibionts, or, his observation may indicate that his shallow-living *A. sp.* has a reproductive strategy different from that of deeper water forms.

The function of the vermiform seventh limb

The function of the vermiform seventh limb, found in all cypridinids, has been the subject of much debate. As early as 1840, Milne-Edwards described the seventh limbs as 'pattes ovifères' (oviferous feet) and ascribed to them an egg-bearing function. This opinion was shared by Baird (1848, 1850), and Claus (1865). Zenker (1854), however, suggested a cleaning function for these appendages. This view was also held by F. Müller (1870) and G. W. Müller (1894). The latter author observed the appendages 'moving over the back, between the gills and particularly between the eggs', and Stebbing (1899) stated that the vermiform limb of *Asterope* is used to clean the inside and outside of the valves, other limbs and the eggs. Skogsberg (1920) reported that the seventh limbs appeared late in ontogeny and were therefore less likely to be exclusively for cleaning than for some aspect of reproduction in maturity. The seventh limb shows only very little sexual dimorphism and its use in egg

care is brought into question since the males are not known to play any part in brood care. However, in *Sarsiella* alone, the male lacks a seventh limb, suggesting that at least in this genus its function, whatever it may be, is essential only to the female.

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